OCTOBER 4, 1961

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Supplement to the "GAS JOURNAL"

Vol. 4 No. 41

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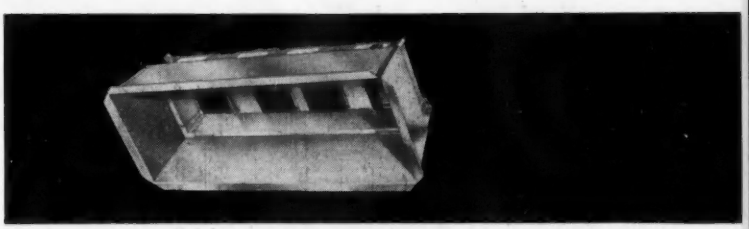

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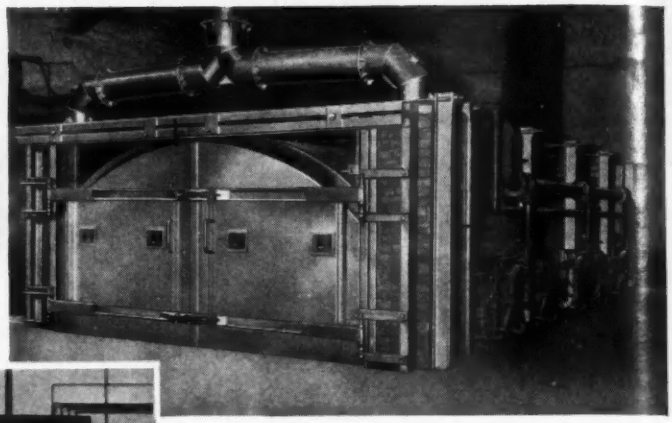

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GAS IN INDUSTRY

OCTOBER 1961

Vol. 4 No. 41

FEATURES

GAS HELPS SKEFKO TO TURN THE WHEELS OF THE WORLD.
By Eric Ford

GAS FOR DRYING AND PRE-HEATING FOUNDRY LADLES.
By G. Holmes and K. G. Rhodes

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Editorial

More applications in the foundry

THE successful extension of the use of gas to industry is always to be encouraged, and it may crop up in unlikely places. The use of gas in the foundry is likely to be extensive especially for starting up a cupola furnace or the drying of sand in the moulding shop, but its use as a means of drying foundry ladles seems a slightly less obvious use for it. But is it?

When we read the paper we are publishing this month on this subject by Mr. G. Holmes and Mr. K. G. Rhodes, of the Manchester Industrial Centre of the North Western Gas Board, we began to realise that here was a useful application for gas in the foundry.

These foundry ladles can hold anything from about 25 lb. to 100 tons of molten metal, and to fill a ladle which has not been properly dried can be most dangerous to anyone standing near the cupola, who might get injured from spluttering metal, and it can have ill effects on the quality of the metal itself. The dissociation of the water vapour will generate hydrogen which may become occluded in the molten metal causing it to become spongy. The importance of ladle drying being established, how was it done in the past, since we understand that it was only two years ago that the Manchester industrial section were called in to give advice on the use of gas for this particular purpose?

Though gas had been tried out by foundry managers previously, it had been on a purely empirical basis using any pipe or tubing that might be to hand without making much attempt to design special appliances. By far the most common means, however, was to light a fire in the ladle and rely on it to evaporate off the moisture in newly set brickwork linings or refractory washes.

Such methods, apart from being utterly primitive in their conception, made the foundry almost unbearable to work in, and at the same time were unreliable. A great deal of time was wasted in keeping the fires alight and often in relighting them.

In addition to drying out the ladle, it is a great advantage to be able to pre-heat it to reduce the chilling of the metal when it first enters the ladle. We feel that the old method cannot have been very easy to regulate in this respect either. Gas would seem to get over all these difficulties and would allow a properly organised ladle 'station' to be set up, at which ladles would be inspected, repaired and dried, followed by a pre-heating period, in the right order and at the right time for the first tapping of the cupola at the beginning of its run.

Since the cost of ladle drying and pre-heating can be a major item in the cost of a casting, it was clearly necessary to carry out experiments to determine the optimum conditions of working, the actual position of the gas burner and the effect of covering the ladle while being dried and heated. The authors conclusively proved their point that properly designed apparatus not only improved the working conditions in the foundry in accordance with the demands of the Factory Acts, but reduced costs too. Timing is all important, and their tests show that with the comparatively large volumes of gas consumed, ten minutes more heating than was necessary would upset all costing estimates.

GAS HELPS SKEFKO TO TURN THE WHEELS OF THE WORLD

★

By

ERIC FORD

SOME of the most vital components of modern machinery and equipment perform their essential duties unseen and are largely taken for granted by those who benefit from their efficient service. Ball and roller bearings, which are incorporated in countless items of machinery, from small domestic equipment to huge steel rolling mills, provide an interesting example.

Indeed, it is not too much to claim that without the various kinds of ball and roller bearings (collectively known as 'rolling bearings') civilisation as we know it today would not have been possible.

Rolling bearing manufacture is a specialised industry, involving a comparatively small number of firms. Undoubtedly one of the best-known of these is the Skefko Ball Bearing Co. Ltd., of Luton.

This British public company is a member of the international SKF organisation, the world's leading manufacturers of ball and roller bearings, with factories in most important industrial countries and a world-wide distribution network.

HIGH QUALITY

In order to give long, trouble-free service under all conditions, rolling bearings must be constructed of the highest quality materials, using precision engineering techniques of the first order. These include the best possible heat treatment processes at appropriate stages of manufacture.

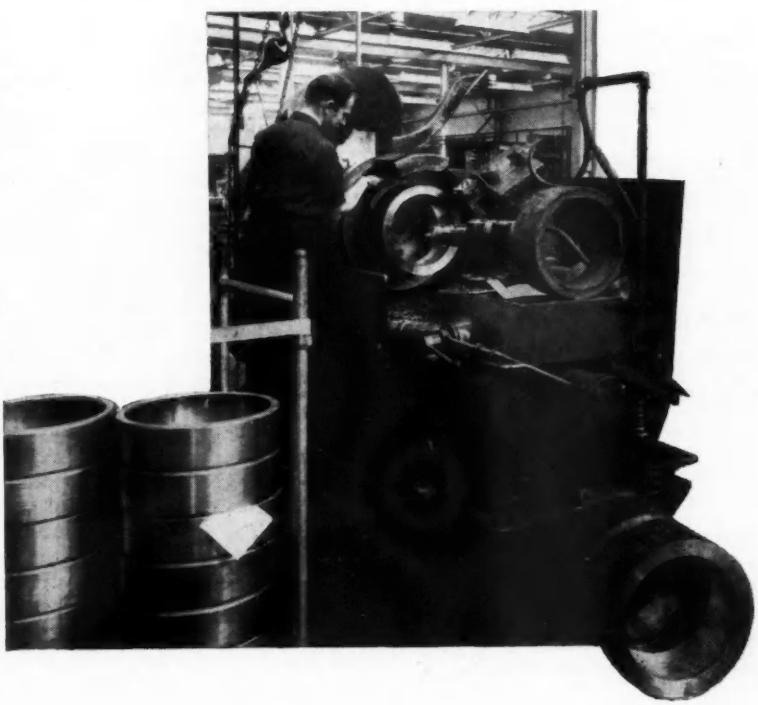
It is therefore of interest to note that the Skefko Ball Bearing Company makes extensive use of gas for this purpose, taking some 60 mill. cu. ft. annually from the Watford Division of the Eastern Gas Board.

Skefko is the only British firm manufacturing all the four basic types of rolling bearings. The ball bearing, not to be confused with the steel balls which are only components of the ball bearing proper, is the type which is best known to the layman.

The other three types are respectively known as the cylindrical roller, taper roller and spherical roller.

Between them, these four basic types (and the many variants within each type) provide suitable bearings for every possible application, of which some of the most important are found in cars and commercial vehicles, locomotives and rolling stock, textile machinery and steel mills.

In particular, the Skefko organisation is especially well-known for the self-aligning ball bearing, which is so designed that it can accommodate misalignment of a shaft. This bear-



Not all rolling bearings are the small components with which the average person is familiar. These large outer rings are being machined at the Skefko Ball Bearing Works, Luton.

A general view of the heat treatment department at the Skefko Ball Bearing Works, where gas is widely used. Note the neat lay-out and clean appearance of this shop.

ing was designed by the Swedish engineer, Sven Wingquist, more than 50 years ago and the company he formed in Sweden, Aktiebolaget Svenska Kullager Fabriken, is the parent of the present world-wide SKF organisation.

WHAT IS MADE

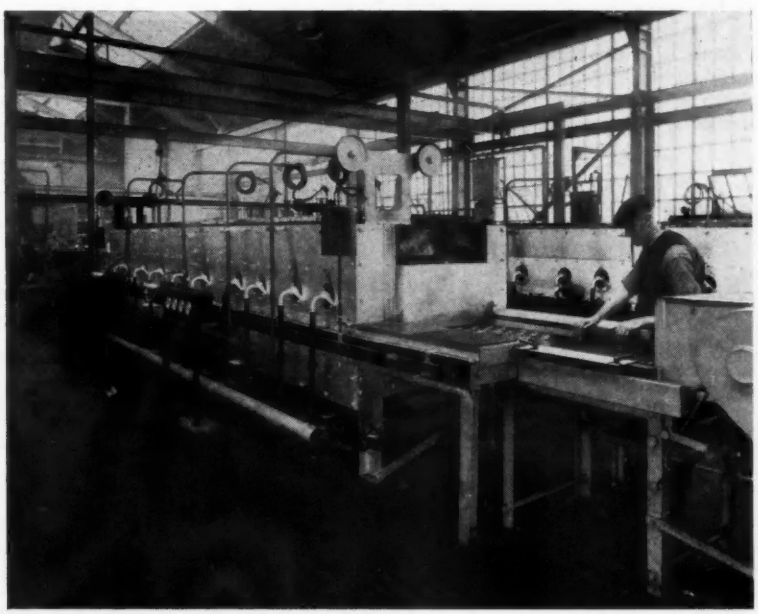
Many varied manufacturing techniques are employed in the production of Skefko's wide range of rolling bearings, but, essentially, the production process demands the manufacture of the balls or rollers, the making of the inner and outer rings between which the rolling elements run, the stamping and shaping of the cages which hold the balls or rollers in place and the assembly and testing of these components.

It is possible in this article to do no more than briefly describe the main processes concerned, bearing in mind that the great variety of components require a bewildering number of different operations.

Consider, for example, the production of the steel balls which constitute such an important part of many rolling bearings. The raw material comes in the form of coils of wire of special high-grade steel and in diameters depending on the size of the ball being produced.

The wire is fed automatically into machines which first cut off suitable lengths and then press it into a sphere.

At this stage, however, the sphere is left with a flange right round its circumference and this is then removed in special grinding machines, employing a rotary filing action. Further grinding operations take place in machines fitted with plates in which a number of annular concentric grooves are cut.



One of the gas-fired furnaces used by Skefko for heat treating inner and outer bearing rings of medium size.

General view of the underground oil quench at the exit point of one of Skefko's gas-fired furnaces.

These plates are subject to heavy wear and have to be re-shaped at appropriate intervals. This operation is carried out in Skefko's own workshops. The worn plate is first annealed in a gas-fired furnace in the heat treatment section, before being re-cut and hardened (also by gas-fired furnace). Plates can be stored and re-used many times before being finally rejected.

After grinding, the balls are then subjected to several tumbling and buffing operations. One of the tumbling operations takes place in a rotary tumbler with an abrasive liquor as the grinding medium, while the final polish is given in tumblers in which leather is the medium.

FINE FINISH

The general effect of these polishing routines is to give the balls an exceptionally fine finish.

Even at this comparatively early stage in the manufacturing process, it is evident that Skefko pay the closest attention to the quality of their products, for the balls are closely inspected for size and sphericity after each operation, with a particularly detailed inspection after polishing.

At this point, a certain proportion of the balls is sold to outside manufacturers, mainly of cycles, while the great majority are assembled into complete ball bearings.

It should be noted that all balls are heat treated at the appropriate stage of manufacture.

Inner and outer rings are made on specially designed automatic machines from steel bar and tube. In Skefko's well-laid out machine shops, the rings, of varying shapes from 8 mm. up to 91 mm. diameter are produced.

The machines, many of which are designed and made by the SKF organisation, have a high output and turn out a precision product.

Some of the larger rings, including those up to 5 ft. in diameter, and shorter runs of smaller types, cannot be economically produced on automatic machines and these are therefore turned in the heavy turning department.

SPECIAL FORGINGS

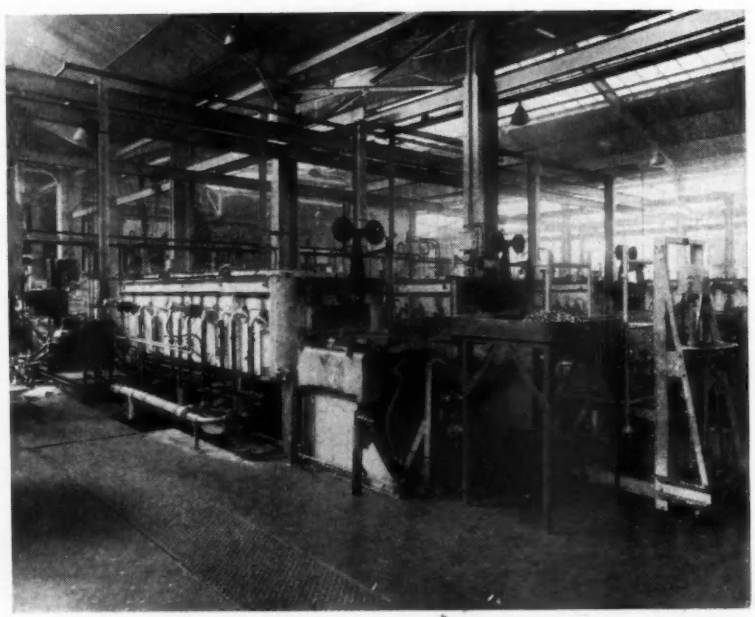
In this department, the rings commence as special forgings in steel or cast iron and all have been carefully designed so that the required final shape is obtained as easily and quickly as possible, using the wide range of machines available.

Before the rings leave the shops for appropriate heat treatment, they are inspected and stamped with the bearing number and other marks of identification.

For example, not only is the component stamped with the SKF trademark, but the fact that it was produced in Great Britain is also indicated.

One more major component requires to be made, namely, the cage. These are produced in the cage department from strip steel, brass or other metal. The cages are stamped out in suitable presses and 'notched' to provide the spaces in which the rollers can be held.

Plummer blocks (for holding bear-



Smaller rings are hardened in gas-fired shaker hearth furnaces of the type shown here.

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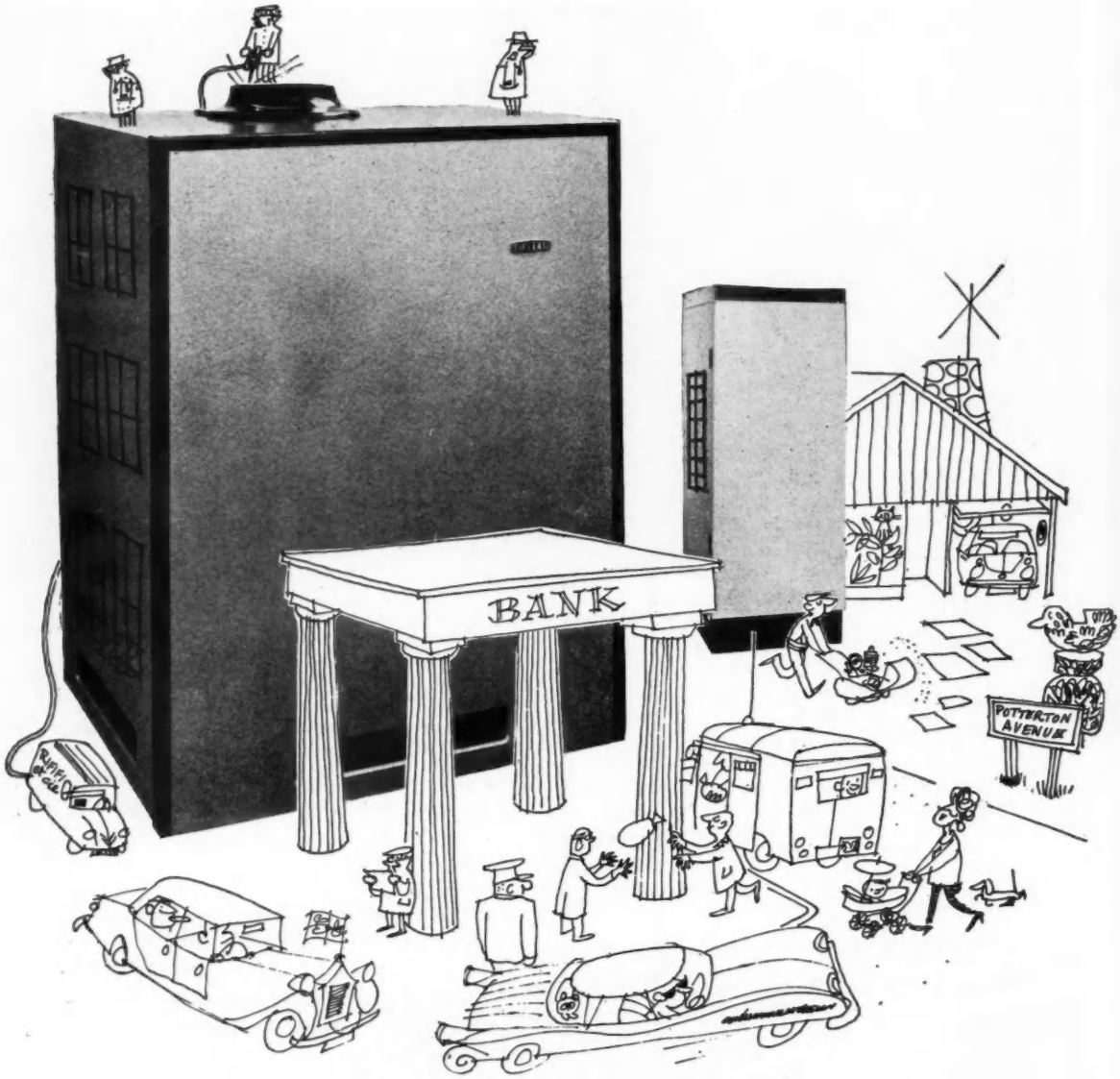

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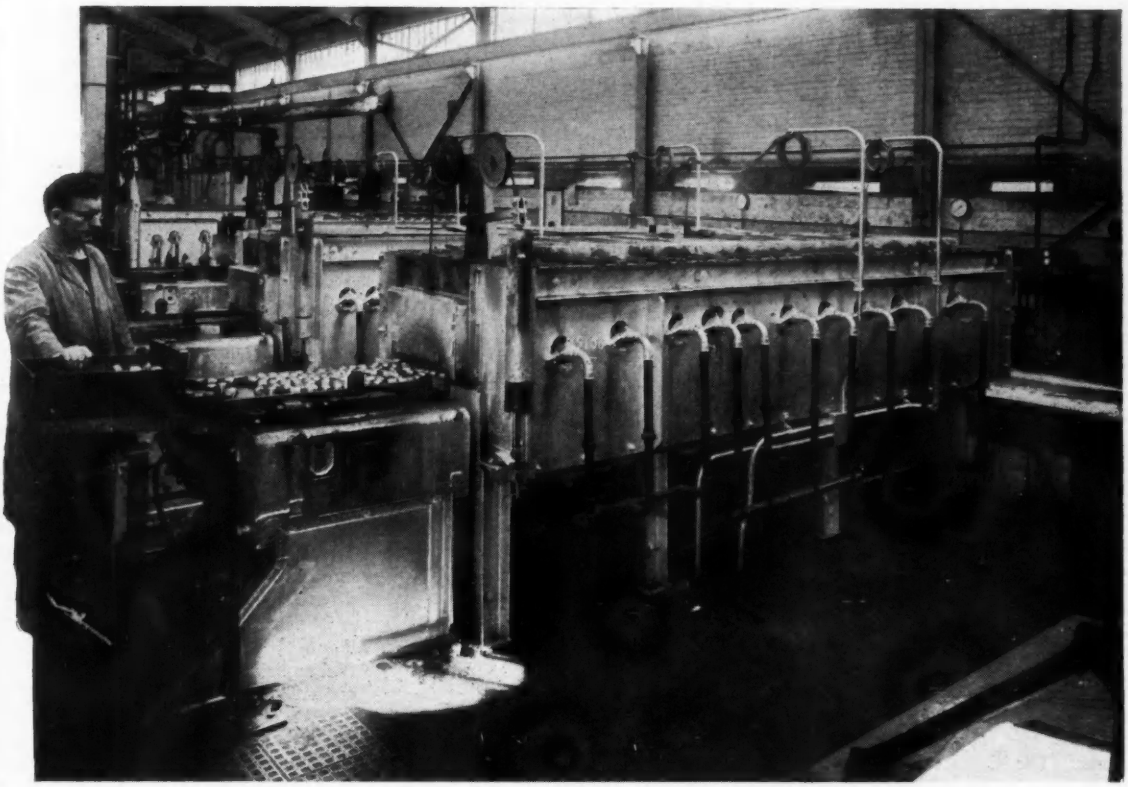


Gas-fired shaker hearth furnaces are also used for the heat treatment of the smaller balls and spherical rollers.

ings) are also produced in the cage department which includes an ICI trichlorethylene degreaser of standard design, which is gas-fired. All components which are to be shot-blasted first pass through the degreaser.

Certain components produced in this department are given normalising treatment in gas-fired furnaces before receiving their final turning operations. This heat treatment, like the other heat treatment operations to which reference has already been made, is provided in Skefko's well-equipped heat treatment department, where the firm's main gas load is found.

This is a self-contained section, which is very well laid out in a spacious, well-lit shop where the equipment is sited in such a way that the flow of components into and out of the furnaces is effected with the minimum of difficulty. This applies both to the continuous and batch-type equipment.

A good example is provided by the roller hearth gas-fired furnaces which are employed on the continuous hardening of inner and outer rings of medium size. The furnaces differ in size and in some minor details of construction but the method of operation is basically the same in each case.

Rings for treatment are loaded into hoppers at the entry end of the roller hearth furnace and taken up on a conveyor and on to the furnace rollers.

This impressive panel contains all the controls for the three gas-fired roller hearth furnaces at the Skefko plant.

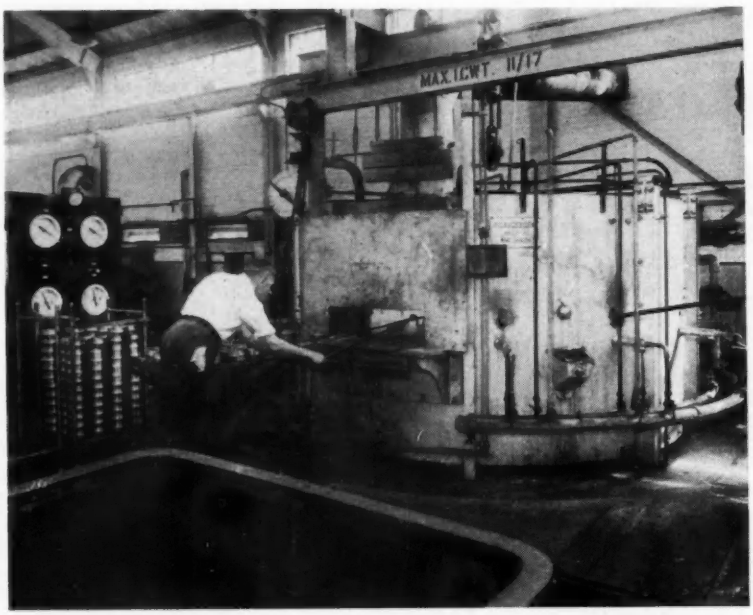
RING SUPPLY

The supply of rings to the rollers is controlled by an ingenious device which stops the conveyor from the hopper when a sufficient number of rings has been delivered to the rollers for entry into the furnace.

Thus, provided the hopper is kept loaded with rings, the furnace is automatically kept supplied with material.

Air/gas burners are situated along each side of these furnaces, being supplied by a suitable mixture controller. The burners fire into the furnace above the work as it moves through the furnace on the rollers.

Each of these furnaces comprises



A rotary hearth furnace, fired by gas, is used at the Skefko works for hardening large rings of more than 180 mm. diameter.

four zones, the first two of these being pre-heat and the last two, soaking zones. The furnaces are highly instrumented to ensure that the correct soaking times and temperature are achieved.

Controllers and controller/recorders for the various zones in all the roller hearth furnaces are neatly arranged on a central control panel, together with the associated equipment for controlling the speed of the roller tracks.

RADIATION HEAD

A radiation head is sited at the exit end of the furnaces to measure and record the final temperature of the work before it enters the oil quench.

The last five rollers of the track run at a faster speed than those before, being driven by a separate chain to achieve this. There is thus no danger of the work being allowed to cool slightly before quenching.

An interesting feature of these furnaces is the method of fitting insulating brick to the top. The bricks have metal bars running through them, transversely to the furnace in a horizontal direction.

When maintenance is required, these bricks can be lifted off in sections by means of the metal bars protruding from each side.

At the end of the furnaces, the oil quench is situated below floor level. The work falls down a chute on to a moving belt below the surface of the oil.

Mechanically-operated agitators maintain the circulation of the oil, the temperature being kept at the required level by movement over cooling coils. If necessary, the number of coils in use can be varied.

The speed of the belt is variable in order to control the temperature of the rings leaving the oil quench.

A conveyor system receives the rings from the oil quench and brings them up in readiness for final quench in a machine in which they are held in a fixture during quenching.

This machine comprises a number of circular compartments which rotate and in turn receive a ring, the roundness of which is controlled by hydraulic pressure.

The ring, having left the previous quench at 180° C. is brought down to about 70° C. by immersion in the oil in this machine.

MEDIUM-SIZED ONLY

Medium-sized rings only are treated in these furnaces, after which they are washed and tempered.

Small rings are heat treated in shaker hearth furnaces which are sited elsewhere in Skefko's large heat treatment section. These furnaces are of Swedish design and comprise three zones, namely, a pre-heat and two soaking zones.

After quenching, these small rings are washed and tempered. Common washing and tempering arrangements are made to meet the requirements of the roller hearth and shaker hearth furnaces.

The work from these furnaces passes through a washing machine and is then tempered at temperatures which vary according to the degree of hardness required.

After tempering, the work is thoroughly tested for hardness and structure, in accordance with the Skefko policy of careful testing of components at all stages of production.

ROTARY HEARTH

Large rings are hardened in a gas fired rotary hearth furnace which handles inner and outer rings of 8 in. diameter and above. This furnace is of conventional design, the method of loading being manual. The speed of the movement of the hearth can be controlled to ensure that the work is heated for the correct time. On completion of the rotary cycle, the work is removed and quenched in a tank sited conveniently for the service of the furnace.

Continuous movement of the oil in the quench tank is ensured by the operation of an agitator at the rear.

After quenching for the first time in this tank, the roundness of the large rings is controlled by hydraulic pressure in a manner similar to that previously described and further quenched down to about 70° C. Washing and tempering operations follow.

HARDENING

Some components are given a Bainite hardening treatment in a gas-fired annular rotary hearth furnace. This process does not require a subsequent tempering operation. Quenching takes place in a molten salt bath, followed by immersion in the salt bath for a period of several hours.

Gas-fired equipment is also employed for hardening balls and rollers, the furnaces used for this purpose being of the shaker hearth type.

Balls and rollers up to ¼ in. diameter are treated in a three-zone furnace, and when they leave the furnace they fall into a quench drum, moving thence down a chute into a metal basket. This container is attached to a weighing mechanism which, when a pre-determined weight

is reached, actuates an alarm, informing the operator that it must be removed and an empty container substituted.

Balls of over ¼ in. diameter and the larger spherical rollers are quenched in a strong salt solution, washed in water (to remove the salt) and then tempered.

Other gas-fired equipment in the heat treatment section at Skefko includes a general purpose annealing furnace, which is used for annealing the pressure plates used for grinding duties in the ball shop prior to being re-cut with their annular concentric grooves (as previously mentioned).

These plates, after re-cutting, are then brought back to the heat treatment section for hardening before being finally returned to service.

From this short survey of the heat treatment equipment available, it is clear that Skefko has the necessary facilities to provide the correct type of controlled heat treatment needed to produce components of the high standard demanded by the company's well-known products.

One of the main impressions the visitor receives from this well-organised department is the ease with which the various components pass through the appropriate processes and leave the department on completion of the cycle for the next stage of the manufacturing process.

In the case of the inner and outer rings, the succeeding operations include various grinding processes and polishing, with frequent inspections to ensure correct dimensions, parallelism of side faces and the like.

Ball and roller bearings are also given further grinding and polishing operations with thorough inspection at all stages.

Every component has therefore been inspected with meticulous care before they all come together in the assembly departments. The larger bearings are assembled mainly by hand and so excellent is the precision work throughout the plant that the balls or rollers, cages and rings fit together within the very fine tolerances permitted.

There is rather more mechanisation in the assembly of the smaller units. For example, the balls are automatically loaded into the cages by special ball-filling machines.

It is after assembly that the completed bearings are given their most stringent tests of all. These tests include gauging of the outside diameter, width, internal clearance and bore and a general check of the running accuracy of the bearing.

When these and other tests have been successfully negotiated, the bearings are cold-dipped in an anti-corrosive solution, wrapped and packed for despatch to the customer.

A visit to the Skefko plant soon shows that the ball bearing is not as simple a piece of mechanism as many suppose. Not only are there many different types of rolling bearing, but the Skefko Ball Bearing Company is always seeking to add to their number by continuous research into methods of improving both the length of life and the operation of the many types of bearing associated with the Company's name.

At the two Luton plants, some 6,000 employees are engaged in the production of SKF products. The welfare arrangements made for their comfort include the provision of excellent canteens, which are serviced by a well-appointed all-gas kitchen.

Expansion is the order of the day and a new Skefko plant will soon be coming into production at Irvine, near Glasgow.

This will shortly be adding its quota to the stream of rolling bearings of all types which are produced by the Company in Great Britain.

Gas is playing its vital role in helping to maintain the Company's justifiable claim that the products of Skefko are to be found 'wherever wheels turn'.

From a paper read to the Manchester District Junior Association of Gas Engineers.

Gas for drying and pre-heating foundry ladles

By G. HOLMES and K. G. RHODES

MANCHESTER GROUP, NORTH WESTERN GAS BOARD.

THE industrial department of the Manchester Group, North Western Gas Board, received an enquiry in 1959 about ladle drying. At the time the enquirer was using gas for drying foundry ladles but was considering changing to electricity.

The authors were asked to carry out various tests on the ladles to determine whether the existing method was the most suitable, and it was only when information connected with previous figures obtained by other engineers was being sought, that they realised how little detail was available on this subject.

Drying and pre-heating

Although the use of gas in the modern foundry has been a subject of many papers in the last ten years, such papers have dealt with the use of gas for general foundry practice, without referring in detail to the drying and pre-heating of foundry ladles; indeed, very little is to be found in the majority of foundry text-books.

The gas load obtained from the drying of ladles is of considerable value to the industry and if the drying is carried out efficiently, it could promote the prestige for gas in the minds of the foundry management.

The casting of metal has been known to man for several thousand years. The early, primitive foundry consisted of a crude furnace from which the metal was directed or channelled direct into the mould. As the art of casting metals progressed, it became necessary to construct larger melting furnaces, and since the distance between the mould and the furnace or cupola made it impracticable to convey the molten metal in channels, the lip-pouring foundry ladle was introduced.

Ladle drying has been practised since the days of the early foundry. Until quite recently, an open fire of wood or any similar combustible matter was burnt in the bottom of the ladle, but besides being thermally inefficient it produced smoke and fumes.

These had deleterious effects on the health of the foundry men, and the method was unreliable. The fires were liable to go out and men spent a large proportion of their time rekindling them. But with wood becoming increasingly expensive and scarce during the last war, gas began to be used more and more.

Though some firms realised the advantages of using gas for ladle drying, they did not seek assistance from either the industrial section or from the appliance manufacturers, so industrial engineers have found some very inefficient installations. In some cases they consisted solely of a piece of wrought iron tube connected to a rubber hose, the open end of which was ignited and inserted into the ladle. Thanks to the efforts of the industrial engineers, the number of such installations is diminishing.

Several sizes

Several types of proprietary ladle dryers are now on the market, some of which have been designed in co-operation with area gas boards. They are available in several sizes to suit ladles up to 60 tons capacity.

Some foundries, however, continued to use wood for drying until prohibited by Regulation 7 (2) of the Iron and Steel Foundries Regulations 1953. These regulations as part of the Factories Act were primarily intended to give a standard of working conditions for safety and health, but they also contribute towards the elimination of smoke, and so assist in complying with the Clean Air Act of 1956.

The Joint Standing Committee of Safety, Health and Welfare conditions in non-ferrous foundries appointed by the Ministry of Labour and National Service recommended in their first report that no open fire should be used for the drying or heating of ladles and crucibles, but that of gas should be used for this purpose.

As a result most foundries now employ gas or oil heating to dry their ladles.

The ladle is an essential piece of equipment used in the foundry to transport the molten metal direct from the cupola to the mould. Its shape is the result of its three duties; it must be able to receive the molten metal easily, be adaptable for quick transportation to the mould and be capable of giving a clean pour into the mould.

Wide at top

All ladles are wide at the top to satisfy the first demand but the method of transportation depends upon the size of the ladle. Hand ladles are made of C.I. or pressed steel and as the name suggests, can be carried by either one or two men using a steel shank or hoop into which the small ladle fits. Single shanks are used for ladles with a capacity of 25 lb. of iron and double shanks for the larger ladles holding 60-120 lb.

An overhead crane is needed to lift the 'bull' ladle which can hold from 5 cwt. to 100 tons of metal. It is built up from boiler plate to withstand the much greater weight of molten metal and is lifted by means of a handle, so fixed to the ladle side that the ladle may be tilted about the handle through 'a pinion' and wheel geared to an operating wheel. A metal guard is placed over the gear wheels to shield them from splashes of molten metal during pouring.

When there are a number of small moulds at a distance away from the cupola, the larger ladle is often used as a reservoir from which the smaller hand ladles can be filled to carry the molten metal to the mould. This decreases the distance for the men to carry the load, and the greater bulk of metal in the larger ladle ensures that the temperature of the metal will be

better maintained. When carried any distance in a ladle, the metal is topped with charcoal to prevent oxidation taking place on the surface layer.

Protection must be given to the boiler plate or C.I. to prevent the molten metal from burning through the outer casing. The thickness of this refractory lining depends on the capacity of the ladle. For up to a 1-ton ladle, a cupola daubing mixture consisting of a thick clay wash is used, which is smeared on to the metal. The clay is pressed hard by hand and is them smoothed on the inside.

Thin lining

The lining should be kept as thin as possible—$\frac{1}{8}$ in. to $\frac{1}{4}$ in. on the sides of hand ladles, but on the bottom this thickness may be doubled since it receives the first fall of the incoming metal. Larger ladles are lined with firebrick, the thickness of which is proportionate to the ladle size. Accuracy in shape and size of the firebrick, is essential to ensure that the joints will be of a minimum thickness. A brick of high density with small pores is ideal where porosity does not exceed 18% by weight (of water absorbed).

The physical properties of the brick should be (a) a high resistance against abrasion by the metal and slag, and (b) the ability to withstand sudden change of temperature without spalling.

Where small breaks do occur, caused by this change in temperature, they should be repaired daily using a daubing mixture to preserve the lining as long as possible.

Clean pour problem

The problem of a clean pour has been tackled in several ways, the cheapest and easiest of which is the simple lip. The metal is poured through a lip at the top of the ladle which is protected by claywash or firebrick to the same degree as the body of the ladle. A skimmer is needed to prevent the surface slag from being carried over with the metal. To obviate the need for a skimmer, the 'teapot spout' ladle was designed, in which the metal is drawn from the bottom of the ladle through the 'spout' leaving the slag in the main body. A similar principle is used in the bottom draw-off ladle which pours through a hole in the base and is controlled by a simple plug operated from the top of the ladle.

Those metals which have to be completely free of slag, such as quality steels, use the modified pouring type of ladle, but for ordinary iron castings the added difficulties of lining the irregularly shaped ladles is not considered worthwhile, and the lip type has proved the most efficient method of obtaining a good pour to the mould.

If molten metal is allowed to enter a wet or even damp ladle, steam is produced which will cause the metal to splutter and endanger the safety of all foundry workers in the vicinity of the cupolas.

To remove all the water from the clay, ladle linings are heated up to a temperature of about 900°C. Failure to heat the ladle to a high temperature before the metal is poured in for the first time, results in the dissociation of the moisture in the ladle lining and the absorption of hydrogen by the molten metal. It is not unknown for steel poured into the mould to rise like dough, due to the hydrogen entering the metal from a newly lined ladle. It is also necessary to pre-heat the dried ladle to a suitable temperature to prevent chilling of the molten metal.

Fireclay ladles

It is generally estimated that fireclay ladles used for conveying molten steel can be used for ten to 12 casts (25-45 acid casts) before re-lining is necessary. In practice it was observed that firebrick lined ladles used for conveying molten iron could be used for approximately 70 casts before re-lining, provided that all cracks were repaired at the start of the day with a skimming of ganister, and the ladle patched when it was found necessary.

Many foundries have established ladle drying stations where, at the end of the day, all ladles are returned to be patched, repaired or rebricked, and finally dried in preparation for the melt the following day.

Ladle stations will vary considerably depending upon the size of the foundry, the method of drying, and whether casting is carried out throughout or for only part of the day.

At the beginning of a normal working day in a ladle drying station, where one or two men will dry approximately six ladles of 2 to 15 tons capacity, the ladles will be inspected to ascertain which, if any, will need to be completely re-lined, those which are to be patched in parts, and those which only need a skimming of ganister before use.

Precedence

Those ladles to be used early in the day must take precedence over the drying of the other ladles, and ladles for re-lining must be set aside to be dealt with later in the day. The selected ladle is then patched, the burner positioned inside the ladle, ignited and left to dry while the workman is preparing another ladle.

In this way all the ladles should be at a suitable temperature to receive the molten metal in the early afternoon when casting usually takes place.

When a ladle has been re-lined it is essential to commence the drying operation with a gentle heat to drive off a major proportion of the moisture in the brickwork and to allow the thermal expansion of the brickwork to take place slowly, eliminating cracks and swellings. Thus a re-lined ladle may take many hours to dry and to raise to a suitable temperature for receiving the molten metal.

It is worthy of note that ladle drying

TABLE 1

Ladle Heating Trials

Fuel	Flow Rate	Heat input (therms/hour)	Ladle temp. °C.	Heating time (mins)	Fuel used	Cost (pence)	CO_2 (%)
Oil	3·3 g.p.h.	5·68	800	34	1·85 gal	31·0	11
			900	—	—	—	11
Oil	4·55 g.p.h.	7·83	800	20	1·55 gal	26·0	12·5
			900	36	2·75 gal	46·1	12·5
Gas	1005 H³/hr.	5·02	800	19	300 ft.³	17·4	10·5
			900	32	520 ft.³	30·2	10·5
Gas	1570 H³/hr.	7·85	800	8	230 ft.³	13·3	8·0
			900	17	430 ft.³	24·9	8·0
Torch hung in Ladle	1650 H³/hr.	8·25	900	50	1380 ft.³	80·2	—

can be most expensive, and can be as much as one third the cupola melting costs, but all efforts to obtain higher efficiencies in ladle drying are worthless if the workman leaves the burner in operation for longer than necessary.

Competition from oil and electricity cannot be overlooked although each has disadvantages to which the utilisation of gas is not prone.

With oil the method of firing gives the main problem. Unlike the gas burner the oil burner should be horizontal, and should fire preferably into a short refractory tunnel which will direct the hot products of combustion into the ladle.

Not practicable

This suggests that the ladle should be either laid on its side or upturned over the flame. Although the latter position for the ladle is ideal for drying efficiently, the hot products being allowed to wash over the ladle sides as they escape, the position is not practicable when large ladles are being dried. Furthermore, since oil must be stored, the ladle must be taken to the burner, and this involves a crane.

In a paper presented to the Combustion Engineering Association J. A. Grainger gave results of ladle heating trials using oil and gas. Both burners fired horizontally into a ladle laid on its side and Table I shows that the use of gas is far more efficient than the use of oil.

Electricity v. gas

The use of electricity for this purpose has few advantages over gas, but these are more than offset by the following disadvantages:

1. Lack of mobility.
2. Longer drying time required per ladle.
3. Maintenance required on the unit.
4. Higher running costs.
5. Higher installation costs.

Compared with the above methods of heating and drying the gas burner is of robust construction and can withstand quite a large amount of rough handling. It is relatively light in weight and can be lifted quite easily and placed into position inside the ladle. It can also be moved to any ladle within a radius of the flexible pipe.

The installation and costs for the gas burner are quite low. Although compressed air is generally available in the foundry, and was used in this instance, the authors strongly recommend the use of fan-air for the gas burners for ladle drying and other processes, on the grounds of its being more economic and control of the burner being more positive.

The industrial section of the Manchester Group were approached by a large consumer with regard to the cost of ladle drying. The firm was already using gas for drying foundry ladles but considered the method they were using could be improved and invited our co-operation.

The existing ladle drying equipment consisted of a simple gas burner, comprising a mixing-tee supplied with low pressure gas and with high pressure air. No burner nozzle was provided, the gas being burnt at the end of the mild steel mixture tube, and the joint between the mixture-tee and mixing-tube was of special construction to enable the burner to be swung about on a horizontal axis. The burner could, therefore, be swung into a position to fire vertically downwards into the ladle. This burner had given many years service and so it was decided to replace it with a Selas 258/2 air blast burner, the flame retention head of which would give a wide range of aerated flames.

Stand design

A stand was designed which enabled the burner to be rotated, or lifted clear of the ladle, and also the height of the nozzle to be altered from the ladle base. The mixture tube was fitted through a sleeve in the stand and thus enabled the burner to move forward or backward in a horizontal plane for its position to be correctly determined.

Ladle drying equipment has three uses, namely for drying ladles which have been completely re-lined, drying those that have been patched and preheating dried ladles.

In order to obtain an efficiency for drying a ladle, the heat input, the heat content of the ladle when dry, and the amount of moisture driven off must be calculated. It was felt that this calculation would prove difficult in practice for the following reasons:

1. The moisture content would be difficult to determine as a suitable weighing machine of sufficient accuracy was not available for the duration of the tests.
2. A constant supply of re-lined ladles was not available.
3. Standardisation is necessary when carrying out any tests and different ladles of the same capacity would vary in weight together with the moisture content.

The only way in which these objections could be overcome would be by raising a dried ladle to a given temperature. It was felt that the primary object of increased efficiencies would be best achieved by obtaining the maximum efficiency in each of the following stages:

1. With both the height of the burner from the base and the area of of the cover of the ladle being constant, the degree of primary aeration be varied.
2. With the degree of aeration giving the maximum efficiency in stage (1) and the area of cover constant, the burner height be varied.
3. Using the degree of aeration as in (2) and the burner height to give maximum efficiency, the area of cover be varied.

It was proposed to raise the temperature to 500° C. without taking into account the fluctuations in the room temperature which would be negligible.

In order to calculate the heat content of the ladle at 500° C. the heat flow through the ladle sides and base would have to be determined, so the temperature of both the interior and exterior of the ladle must be known. By burying the thermocouples below the surface of the refractory lining it would eliminate having to allow for the reduction in heat transfer caused by the static film of gas adjacent to the refractory surface. The external temperatures could be obtained with a surface pyrometer.

Degree of aeration

To obtain the degree of aeration it would be necessary to take samples of the coal gas and gas/air mixture in sampling bottles for analysis at the completion of each test.

There was every hope that the data obtained from these tests would be sufficient to calculate the efficiency of each test and thereby obtain the maximum efficiency. We were therefore given every assistance possible by the consumer. A 5-ton lip pouring ladle was put at our disposal, and a small office was made available in which we could carry out gas analyses, and store sampling and temperature indicating apparatus.

The ladle was first dried and allowed to cool. The cooling took several hours, so it was soon realised that a maximum of only one test a day could be carried out When the ladle was cool, two thermocouples of the iron-

constantan type were grouted into the ladle side and base.

The first test to be carried out was to be concerned with varying degrees of aeration, the area of cover and the height of the burner being kept constant as previously described. After the burner had been adjusted to give a lambent flame, the gas consumption, the gas mixture and the air pressures were recorded, the internal temperatures of the ladle being recorded every five minutes. Samples of the coal gas, gas/air mixture and the products of combustion were taken during the test and the time taken for the ladle to reach 520°C. on the side thermocouple was recorded and a time/temperature curve plotted.

From the coal gas analysis shown in Table 2 the theoretical amount of air required for complete combustion was calculated. The degree of aeration was found to be 30.69%.

TABLE 2

Air required for combustion

Constituent	I. Per cent by volume	II. Volume of oxygen for combustion of 1 volume gas	Col. I × Col. II / 100
Oxygen	1·0	−1	−·01
Carbon dioxide	3·6	—	—
Nitrogen	14·0	—	—
Unsaturated hydrocarbons (C_3H_6)	2·7	4·5	·1215
Hydrogen	46·4	·5	·2320
Methane	16·0	2·0	·3200
Carbon monoxide	15·6	·5	·0780
Saturated hydrocarbons (C_2H_6)	·7	3·5	·0245

In order to calculate the efficiency of pre-heating a ladle it is necessary to calculate the heat content of the ladle walls and base. The internal wall temperature was 968°F. on the side thermocouple and 1,453°F. on the base thermocouple and the surface temperature of the external wall was 170°F. First the heat flow through the walls must be calculated together with the junction temperatures of the composite layers in the ladle walls.

The heat content of the ladle was calculated and found to be 117,427 B.t.u. made up of 74,811 B.t.u. in the side and 42,616 B.t.u. in the base. The gas consumption was 694 cu.ft. and the thermal efficiency 37.7%. This low figure of 37.7% from this the first test indicated that there was scope for obtaining increased efficiencies.

The burner was next adjusted to give a bunsen type flame having a blue inner cone approximately 18 in. long with 65.48% aeration. This gave the maximum efficiency of 39.8% in this the first stage. Further tests with the burner adjusted to give an over aerated flame of 113.7% aeration and 146% aeration, resulted in efficiencies of 39.1% and 34.2% respectively.

The second stage in the tests was to determine the effect of burner height on the efficiency of the heating operation, using the flame which gave the maximum efficiency in the previous test.

The aeration tests were conducted with the burner in the lowest possible position, *i.e.* 19.5 in. from the base of the ladle or 52.7% of the ladle depth. The construction of the burner unit made it impossible to lower the burner below this position. This may not have been desirable, however, since the blue cone was 18 in. long and would have impinged on the base of the ladle thereby interfering with combustion. The burner was raised approximately 3 in. for each test and showed a decrease in efficiency for increase in height. These readings were plotted and the curve so produced appears to reach a maximum efficiency at approximately 50% of the ladle height. This is comparable with the optimum efficiency obtained at 52.7% of the height realised in these tests.

The final stage in these series of tests was to determine the maximum amount of cover that could be placed over the top of the ladle to give the maximum efficiency, without causing any baffling of the flame, and to determine the effect that the area of cover would have on the thermal efficiency.

The degree of aeration and height of burner which gave the highest efficiencies in stages (1) and (2) were used. The area of cover was varied by increasing the area of a 30-in. diameter circular mild steel plate with firebricks placed radially between the circumference of the plate and that of the ladle.

The maximum area of cover possible, without causing baffling of the flames was found to be 91.8% of the area of the ladle top. With this area of cover in position, an analysis of the products of combustion showed that the carbon dioxide content had increased to 11.7% and thus the amount of excess air entrained was greatly reduced. From these analyses it was realised that the thermal efficiency would be increased, and was later calculated to be 58%.

It had been hoped to show conclusively the marked effect that varying the area of the cover had on the thermal efficiency, but unfortunately the shortage of time prevented the completion of the tests. However, the results obtained were plotted.

In practice it was observed that as soon as the ladle was dry the burner was removed together with the cover for another ladle. This allowed the heated ladle to cool gradually until the cupolas were tapped.

A ladle was heated to 520°C. on the side thermo-couple, the burner shut off, and the cover removed. The time/temperature readings were plotted to form the cooling curves.

The results of the tests carried out to improve the drying and pre-heating of foundry ladles indicate the following recommendations.

1. That insulating covers should be provided to place over the dried or heated ladle until required for use. It is felt that this recommendation would conserve much heat energy which would otherwise be lost.
2. That covers of the correct area, preferably of a suitable insulating material, provided with a slot for inserting the burner, should be provided for use during the drying of the ladles. The previous tests proved that an area of cover of 91.2% would be suitable, but not so in practice since the burner was almost at the point of baffling and a certain degree of safety must be allowed for, even at a loss in efficiency.
3. That the burner be shut off and removed from the ladle as soon as the ladle is dried.
   The burner used in these tests consumed approximately 10 cu.ft. of gas per minute and thus if the burner is left ignited in a ladle which is dry for an extra 10 minutes until the next ladle is ready for drying, then an increase in efficiency of 25% obtained by improved methods would be nullified.
4. The heating of the ladles should be programmed so that they reach the required temperature at the time when they are required to receive the molten metal.

250 LUNCHES AND 1,000 CUPS OF TEA—BY GAS

UP-TO-DATE EQUIPMENT

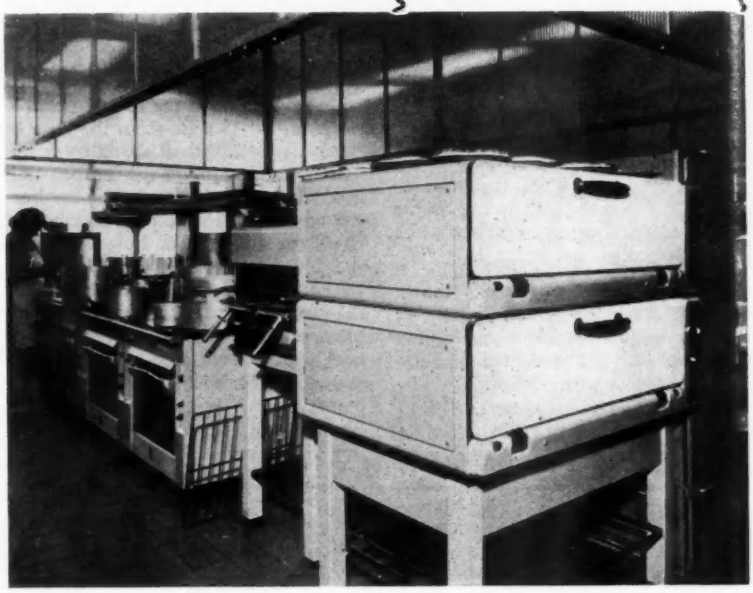
EVERY day, 250 hot lunches are served to employees at the Worcester engineering works of Heenan and Froude Ltd. In addition the kitchen staff make 1,000 cups of tea for the morning and afternoon breaks.

For such a job gas is ideal and that is what the firm chose. All the equipment was fitted by Worcester District, says 'Viewpoint,' a news Bulletin issued by the West Midlands Gas Board.

It includes chip fryers, pastry ovens, griller, range, stock pot, steamers and a hot water storage cylinder.

Gas-heated bain marie and hotcupboards are fixed in the 40-ft. long counter in the dining room. Diners collect their meals on the 'serve yourself' principle and pay the cashier on the way to their table.

The chef's opinion: 'Give me gas every time for speed and flexibility.'

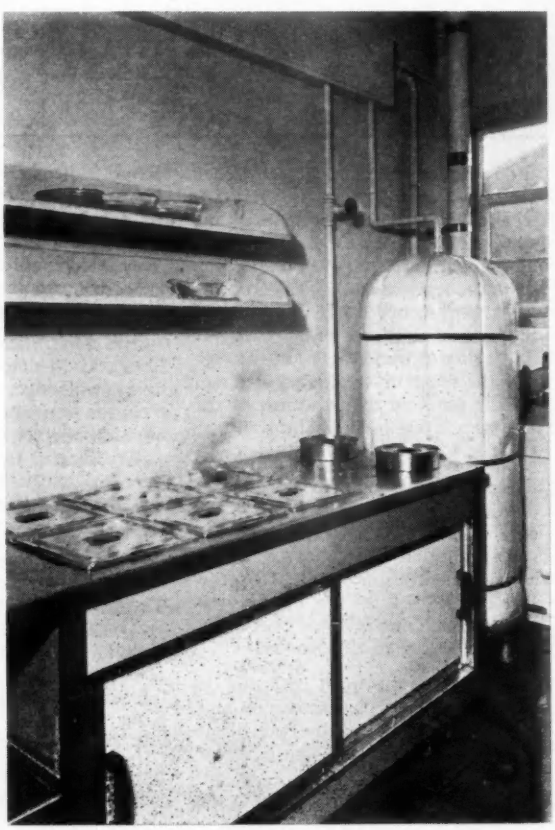


AN ALL-GAS KITCHEN

A view of the all-gas kitchen at the Heenan & Froude works canteen.

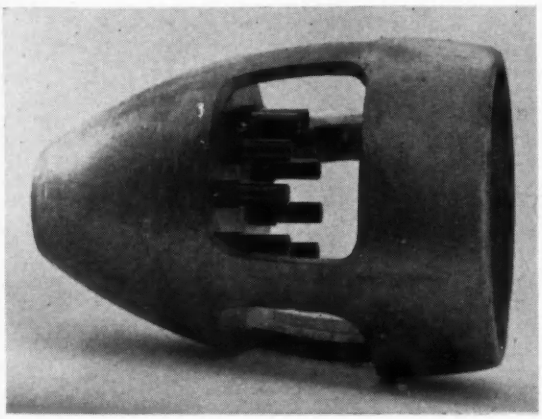
Gas cooks the meals. The Worcester District staff fitted the gas equipment, some of which is seen above.

Gas heats the water for washing up (right). This shows the storage cylinder.



Gas fish fryers are included in the Heenan & Froude kitchen equipment.

New tube-firing gas burner for immersion heaters



A tube-firing burner for immersion heaters by W. H. Rowe & Son Ltd., Southampton.

***A** NEW tube-firing gas burner for immersion heaters is announced by W. H. Rowe & Son, Ltd., Quayside Road, Bitterne Manor, Southampton.*

It has been developed by the Company, with the co-operation of the Southern Gas Board, to meet the need for an efficient and inexpensive method of tank heating in all cases where immersion tubes can be installed.

The burner is fitted to the tube extension ouside the tank and located by means of the set screw. Controls and gas supply are then connected to the burner.

Gas at mains pressure is employed and fires round the inner circumference of the tube to prevent short-circuiting of cold air.

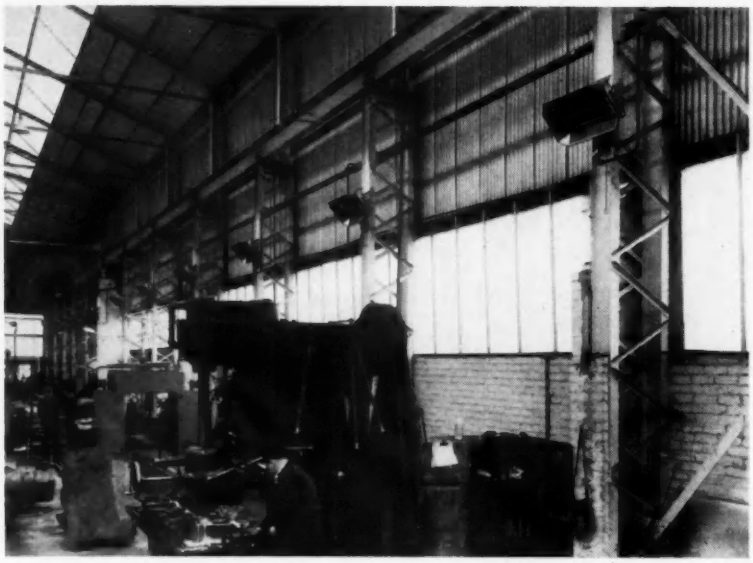
The burner which is 7¼ in. long overall, is available in a range of sizes to fit tubes from 2-6 in. dia. The burner is fitted with a pilot jet and can be equipped with a thermo-electric flame-protection device if required.

Thermostatic control can also be employed.

Retail prices range from £4 17s. 6d. for the 2-in. diameter burner, which is equipped with 5 jets, to £12 5s. for the 38 jet 6-in dia. model.

Another view of the tube - firing burner announced by W. H. Rowe & Son Ltd.

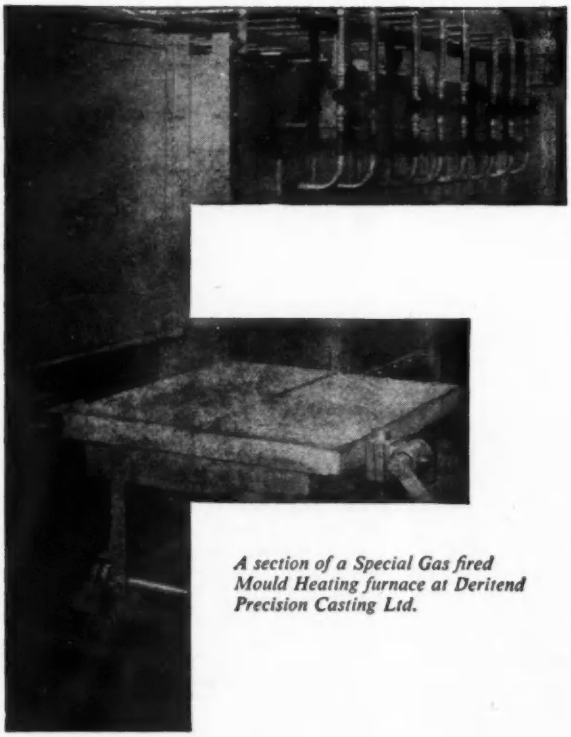
NORTHERN GAS BOARD, TYNESIDE DIVISION, INSTALLS OVERHEAD RADIANT HEATING FOR TOOLS FIRM



BETWEEN September 1960 and March 1961 the Tyneside Division of Northern Gas Board has carried out extensive overhead heating installations in the machine shop of Pearson's Machine Tools, Wallsend-on-Tyne, using exclusively equipment supplied by Radiant Heating Ltd., of Coventry.

The work was carried out in three schemes and involved 148 heaters of different types, capable of producing an impressive total heat input of 7,750,000 B.t.u. over an approximate total floor area of 82,000 sq.ft.

The measure of success which this operation has met is shown by the fact that a further installation of 14 Radiant heaters is being planned at Pearson's Machine Tools in a smaller shop and in the extension to the main shop.



A section of a Special Gas fired Mould Heating furnace at Deritend Precision Casting Ltd.

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There's big savings in terms of dependability and easy maintenance when Franklin are called in on that furnace installation. Long experience in the supply of standard, and the design of special furnaces mean the snags are quickly ironed out. Furnaces fired by 'Dine' Burners give easy maintenance and fuel economy, that's why more and more well-known Companies are now counted as customers.
Our team of experts would welcome the chance to look into your furnace problems.

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